

STUDY OF POISON GAS OCCURRENCE AND WATER QUALITY WITHIN BAUXITE-CARRYING BARGE AT KIJANG ISLAND

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ABSTRACT

An accident occurred in bauxite-carrying barge at Kijang Island that caused the death of 3 workers urged Mining Business Unit for Bauxite of PT Aneka Tambang to ask RDCMCT to conduct a series research on the barge. Observation on the site sampled gas and water. Results presented that NO₂, SO₂ and CO contents were still the threshold value as stated in a circular of Minister of Manpower no. SE.01/MEN/1997. Seawater analyses showed that all elements were still below the allowed figures except for nitrogen-ammonia (N-NH₃) that exceeded the threshold value (0.213-0.47 mg/l). Based on observation on the site and laboratory analyses, oxygen deficiency within compartment was the caused of the worker death.

1. INTRODUCTION

Mining Business Unit for Bauxite of PT Aneka Tambang mines bauxite ore at Kijang Island. Generally, the material is transported from mining area using a dump truck but if road condition is not good enough, the material is sent to the washing plant by a flat-bottomed steel barge that performs capacity of 175 metric tons. The barge consists of 14 compartments available at the bottom deck. Of the 14 compartments, 7 compartments are placed on the right deck and the rest on the left side. The compartment is partitioned and sealed from each other in order to make the barge balanced. Every compartment has oval-shape admission opening (manhole) with longest diameter 59 cm and shortest diameter 38 cm. Each manhole is tightly close by nut and bolt and sealed by rubber to prevent sea water and rainfall entering the chamber. Each manhole has an air-duct to allow air circulation during hot and cold weather. In a specified period, barge condition is checked for repairing – if any – the damage.

On May 28, 2001, local inspector of Mining Business Unit for Bauxite found that Palma II – the barge, was inclined although all bauxite ores had been unloaded. The inspector asked maintenance

section to search for leakage possibility by opening all manholes. It was found that compartment number 3 and 4 were filled by water as high as 1.50 m. The barge was pulled onto the beach and seawater from the leakage compartment was pumped using a portable pump by 3 workers. Pumping was conducted during daytime where the atmosphere around sea was very hot. Hot weather lured one worker to plunge into the water for cooling himself off. He was found unconscious by two other workers who immediately helped him and then the tragedy occurred. The three workers were found dead. This accident happened was categorized as an accident of mine causing death. Such a tragedy motivated Mining Business Unit for Bauxite of PT Aneka Tambang to ask R&D for Mineral and Coal Technology to conduct a study of poison gas occurrence and toxic water in barge compartment.

2. METHOD

In-situ research conducts several activities that include:

- observation on Palma II and another barge that has similar case to Palma II;

- gas and water sampling from every compartment;
- water acidity measurement from every compartment.

Ex-situ research conducts several laboratory analyses in Bandung.

3. RESULTS AND DISCUSSION

Gas samples were taken from 4 compartments of 2 different barges, namely Transmedia 24 and Guang Zinc 138. Permission to use of both barges was granted by PT Aneka Tambang Tbk. Sampling could not be conducted at Palma II due to compartments of Palma II had already opened when evacuating the victims. This condition affected water and atmosphere within compartment.

Gas samples that were taken from Transmedia 24 and Guang Zinc 138 shows that (Table 1) the quality of NO₂, SO₂ and of CO from every compartment are low enough and still below threshold value for gas in working area as stated in a circular of Minister of Manpower no. SE.01/MEN/1997. Concentrations of NO₂, SO₂ and CO are low enough as the barges retain no machines and are only pulled by tug boats. Therefore, it is less possible that gas residue from the tug boats the tightly closed compartment sealed rubber. Air contamination within compartment is supposed to occur due to metabolism of anaerobe and/or aerobe bacteria activities inside compartment. The anaerobe bacteria available in water oxidize organic compounds and yield various gases such as CO₂, H₂O, H₂S, CH₄, NH₃ and N₂; while aerobe bacteria consume free oxygen from the atmosphere or the air bubble and produce CO₂, H₂O, H₂S, CH₄, NH₃ and N₂ gases. All gasses are then accumulated and react to form poisonous gas compounds that will kill the living creatures (Wardhana, 1995).

Corrosion producing rusts is another possibility to cause low quality of the air within compartments. However, company investigation on Palma II, conducted by measuring the gases and using live chicken, showed that CO and SO₂ concentration of 14 compartments were nil ppm and the chicken was still alive. The already opened compartment seems the cause for low concentrations of CO and SO₂.

It is possible that the worker death occurred due to corrosion process and fermentation inside the

Table 1. Results of gas analyses in compartment of barge

No	Barge name	Location	Sampling Point (from top side)	Time	Concentration						Note
					NO ₂		SO ₂		CO		
					(µg/m ³)	ppm	(µg/m ³)	ppm	(µg/m ³)	ppm	
1.	Tongkang Tarnsmedia 24 Size: 180 x 50 ft Owner : CV. Intansari	Right Bounce Compartment No. 10	1.20 m	12.05	152.345	0.4231	174.271	0.0068	69.079	60.399	Compartment has water
			2.90 m	12.30	79.830	0.2218	87.135	0.0033	34.539	30.205	
2.	Tongkang Guang Seng 138 Size : 180 x 50 ft Owner: PT Intinsinarindo B	Right Bounce Compartment No. 12	1.20 m	15.50	302.346	0.8399	348.543	0.0133	138.158	120.890	Compartment is dry
			2.90 m	16.20	162.403	0.4511	174.271	0.0066	66.908	60.400	
		Left Bounce Compartment No. 4	1.20 m	09.45	102.305	0.2842	130.703	0.0056	20.723	18.100	Compartment has water
			2.90 m	10.15	352.046	0.9779	392.111	0.0150	10.362	0.9070	
		Left Bounce Compartment No. 1	1.20 m	11.25	54.234	0.1507	65.351	0.0025	10.362	0.9070	Compartment has water
			2.90 m	12.25	145.004	0.4028	196.055	0.0075	0.5181	0.4535	
Threshold value					5.600	3	5.200	2	29.000	25	

Source : Primary data, based on analytical results of Balai HIPERKES & KK West Java Province.

compartment. The process yields thin oxygen that causes people to be short-winded and dizzy. When this happened to the workers on Palma II, they were unconscious, fell down into the water and then drowned. Gas measurement results that indicate below the threshold are not a guarantee that the place is safe and sound.

Water analyses were conducted to support air quality data. It is important to observe water quality in terms of estimating gas source. Gas occurrence within compartment was supposed to be happened due to bacteria-metabolism activities within water (Samuelson, 1980). The produced gases were then released to the air. Samples taken from compartment 1, 4 and 13 of Guang Zinc 138 and compartment 10 of Transmedia 24 are shown in Table 2.

Physical parameters of water analyses consist of total solid suspension (TSS), and total solid dissolved (TDS). Analysis results indicate that the in-situ TTS content varies from 9.0 to 148.6 mg/l. The highest value of TTS occurred in compartment 4 and the lowest value was in compartment 13. TSS in compartment 4 had exceeded the threshold value of environmental quality standard for sea biota (80 mg/l). Mud came from bauxite fell into the sea and then re-entered the compartment through the hole linkage seemed the culprit for high TSS. Analyzing evaporated-filtrate residue shows that the solid percentage in seawater is high enough. Varied sea water content such as inorganic and organic salts and other dissolve compounds as well is responsible for high content of solid percentage. The dissolved solids in 4 locations vary between 34.215 - 44.115 mg/l.

Table 2. Water quality in barge compartment

No	Param.	Unit	Method	Analysis Results				Thres. v. for seawater*)
Physical Analyses				C1	C4	C13	C10	
1.	TDS	mg/l	Gravimetry	44,11	34,98	34,12	35,83	-
2.	TSS	mg/l	Gravimetry	31.00	148.60+	30.00	9.00	£ 80
Chemical Analyses								
1.	pH	-		7.5	7.4	8.5	9.4	06-Sep
2.	COD	mg/l	Reflux	40.67+	46.67+	58.33+	36.0	£ 40
3.	NH ₃ -N	mg/l	Spectrophot	0.47+	0.213+	0.303+	0.257+	£ 0.1
4.	NO ₃ -N	mg/l	Spectrophot	0.023	0.072	0.038	0.056	-
5.	NO ₂ -N	mg/l	Spectrophot	0.009	0.033	0.003	0.003	-
6.	H ₂ S	mg/l	Spectrophot	nd	nd	nd	nd	£ 0.03
7.	Sulfate (SO ₄)	mg/l	Spectrophot	2,211	79.25	1,6245	568.5	-
8.	Iron (Fe)	mg/l	AAS	2.44	14.8	5.3	2.17	-
9.	Lead (Pb)	mg/l	AAS	0.11+	0.07+	0.11+	0.07+	£ 0.05
10.	Copper (Cu)	mg/l	AAS	0.015	0.012	0.009	0.007	£ 0.06

Note :

nd = not detected; the values is less than 0.01

*) = State Ministerial Decree of Environmental Affairs no.22/MENKLH/I/1988 regarding quality standard for sea water

+ = exceeding standard of quality

The value of acidity degree (pH) presents about acidity -alkalinity balance by measuring H^+ concentration. Seawater generally has pH range around 8 – 8.3. Supporting capacity of seawater is especially determined by silicate ions. Analysis indicates that seawater pH ranges from 7.4 to 9.4 while the pH threshold for seawater is 6 - 9. Compartment 13 retains pH higher than that of pH threshold for sea water (9.4). This was caused by alkaline compounds that entered compartment.

COD analyses for 4 locations range from 36.00 – 58.33 mg/l. Quality standard of COD for seawater is ≤ 40 mg/l. It seems that seawater within compartment number 1, 4 and 10 have exceeded the threshold. This means that degradation of seawater quality in the three chambers occurred. The COD in compartment number 13 is still below the threshold.

Ammonia is one of nitrogen compounds formed in seawater as a reduced compound. This compound performs as either NH_3 or NH_4 . If seawater pH is equal to 8.2 or lesser, the ammonia will be in NH_4^+ performance. Pescod (1973) states that NH_3 is a toxic compound for either fishes or other seawater biota. N- NH_3 content at location ranges from 0.213 to 0.47 mg/l. Such a figure exceeds the threshold of N- NH_3 quality standard for sea environment (< 0.1 mg/l). The change of nitrate to nitrite in anaerobe condition or protein decomposition of the creature in both aerobe and anaerobe condition by saprophytic bacteria seem responsible for the high content of ammonia in sea water. NH_3 evaporation from sea water enter the compartment through the air

As unstable compound, N - NO_2 or nitrite is found in a very small number within seawater. It is easily change into ammonia, nitrate or nitrogen. High concentration of nitrite is supposed to be come from domestic wastes in estuary area. Nitrite analy-

sis of sea water ranges from 0.003 – 0.033 mg/l. Oxidized perfectly, nitrogen performs a stable nitrate compound along with dissolved oxygen in the water. The compound is a micro nutrient for primary productivity occurs at euphotic zone of the sea. The detected nitrate varies from 0,023 - 0,072 mg/l.

Hydrogen sulfide results from sulfate decomposition that occurs in anaerobic condition by bacteria. However, the compound is not available at the site. Compared to other anions within sea water, sulfate retains bigger concentration. The anion is not toxic actually for either sea water biota or human. Yet accumulated concentration of sulfate will generate bad odor and corrosive. Sulfate reduction occurs due to bacteria activities in anaerobic condition. Test results show that sulfate content ranges from 79.25 - 221 mg/l. Compartment number 1 retains the highest sulfate content and compartment number 4 is the lowest one.

Fe content ranges from 2.17 - 14 mg/l and Cu content varies from 0.007 – 0.015 mg/l. Lead content ranges from 0.07 – 0.063 mg/l. Fe and Cu are still under the threshold value but Pb has exceeded the allowed value for sea biota. High concentration of Pb is estimated from ship wastes, industrial disposal and domestic wastes that enter territorial seawater either directly or indirectly through the rivers.

Table 3 illustrates microbiological analysis. It indicates that aerobic and anaerobic bacteria were not detected within samples. Expired samples is supposed to be the culprit as they were kept more than 48 hours. However, seawater naturally retains bacteria such as is pleomorphic - the negative gram bacteria especially the motile type, psychrophiles from the genus of *Vibrio* or *Mycoplasma* (Frobisher, et al., 1974).

Table 3. Microbiological analysis

No.	Compartment	Amount of bacteria (cel/ml)	
		Aerobic	Anaerobic
1.	1	none	none
2.	4	none	none
3.	10	none	none
4.	13	none	none

4. CONCLUSIONS

NO₂, SO₂ and CO in compartment 1, 4, 10 and 13 are still under the threshold value for gas. The death of three workers is supposed to be result from oxygen deficiency instead of the three gasses above. However, testing on COD, ammonia and Pb metal of water sample shows that all mentioned parameters retain higher number, exceeding the allowed value for sea water biota.

Microbiological process in water is supposed to be play an important role in poison gas formation such as ammonia. This results in oxygen deficiency and needs blowing fresh air prior to repairing the barge. However, the bacteria were not found within water samples as the samples were expired.

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